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Inventor: Masanobu Matsuoka
Mitsubishi Seishi K.K., 4-2 3-chome Marunouchi, Chiyoda-ku, Tokyo, Japan
Inventor: Masayuki Oku
Mitsubishi Seishi K.K., 4-2 3-chome Marunouchi, Chiyoda-ku, Tokyo, Japan
Applicant: Mitsubishi Seishi K.K.
4-2 3-chome Marunouchi, Chiyoda-ku, Tokyo, Japan

Detailed Report

(Name of the invention)

Hydrophilic nonwoven fabric

(Object of the invention)

The object of this invention is to offer a hydrophilic nonwoven fabric which is extremely hydrophilic which lasts over time and also has excellent mechanical properties such as breaking strength. This invention also offers extremely effective wipers which use this nonwoven fabric.

(Solution)

Hydrophilic nonwoven fabric, which is acquired by applying an electric

discharge plasma process to nonwoven fabric that consists of either single or mixed synthetic fibers or semi-synthetic fiber which have been kneaded and mixed with a hydrophilic agent.

(Sphere of patent request)

(Claim 1)
Claim 1 is concerning hydrophilic nonwoven fabric with the following characteristics. Hydrophilic properties of the nonwoven fabric are improved by a plasma electric discharge process> The nonwoven fabric consists of either single or mixed synthetic or semi-synthetic fiber which has been kneaded and mixed with a hydrophilic agent.

(Claim 2)

Claim 2 is concerning the hydrophilic nonwoven fabric in claim 1 where the base fiber is hydrophobic fiber.

(Claim 3)

Claim 3 is concerning the hydrophilic nonwoven fabric in claims 1 and 2 where the base fiber is polyolefin or polyester fiber.

(Claim 4)

Claim 4 is concerning the hydrophilic nonwoven fabric in claims 1 to 3 where the plasma electric discharge process is a corona treatment and the treatment is given to one side or both sides of the nonwoven fabric.

(Claim 5)

Claim 5 is concerning the hydrophilic nonwoven fabric in claims 1 to 4 where the corona electric discharge process is 0.05 to 2.0 KW min./m^2 total energy per each side.

(Claim 6)

Claim 6 is concerning the hydrophilic nonwoven fabric in claims 1 to 5 where the base fiber is 0.03 to 1.5 denier.

(Claim 7)

Claim 7 is concerning a wiper which consists of the hydrophilic nonwoven fabric

in any of the above claims 1 to 6.

Detailed explanation of the invention

[0001]

(Technical field of use)

This invention is concerning a fiber sheet which makes nonwoven fabric that uses synthetic or semi-synthetic fiber hydrophilic and a manufacturing method for the same. In more detail, it is concerning a nonwoven fabric with excellent hydrophilic properties which do not deteriorate over time, It also has excellent mechanical properties such as breaking strength. This invention also offers wipers which uses this nonwoven fabric.

[0002]

(Prior art)

Synthetic or semi-synthetic fiber has various excellent features. However, it is hydrophobic and does not diffuse water. Applications for this nonwoven fabric are limited. In order to solve such problems, much research has been done already.

[0003] One method to make nonwoven fabric which uses synthetic fiber hydrophilic is to use surfactant. However, when this material is used as a wipe with water or detergent, the surfactant flows out and contaminates the cleaned surface.

[0004] Another method to make synthetic fiber hydrophilic is to melt and blend synthetic fiber and a hydrophilic agent when the thread is formed. However, with this method, in order to obtain fiber which has sufficient hydrophilic nature, it is necessary to use a lot of hydrophilic agent. This causes process stability problems with the thread making process. Not only that, even if nonwoven fabric is formed using this fiber, its strength is low.

[0005] A plasma electric discharge process to treat nonwoven fabric which uses synthetic fiber is suggested in Japan patent No. H 8-311765. By this method, even though good hydrophilic properties are attained right after the plasma electric discharge process, the hydrophilic nature will deteriorate as time goes by. After a long period of time such as half year, it will lose its hydrophilic nature.

[0006]

(Problems that this invention tries to solve)

In order to solve the above problems with the prior art, this invention offers a hydrophilic nonwoven fabric with excellent hydrophilic properties, less hydrophilic

deterioration due to time, and excellent mechanical properties such as breaking strength. This invention also offers an excellent wiper using this nonwoven fabric.

[0007]

(Steps for solution)

In order to solve the above problems, through research has been done. As a result, the nonwoven fabric of this invention was developed. The effects of this invention can be attained by performing a plasma electric discharge process on nonwoven fabric that consists of either single or mixed synthetic or semi-synthetic fiber which has been kneaded and mixed with a hydrophilic agent.

[0008] The base fiber used in this invention should be a hydrophobic fiber. It is preferred that these base fibers are polyolefin or polyester based fibers.

[0009] In addition, the plasma electric discharge process should be a corona electric discharge process and the nonwoven fabric should be treated on one or both sides.

[0010] the corona electric discharge process conditions should provide 0.05 to 2.0 KW min./m^2 total energy per side.

[0011] The base fiber should be 0.03 to 1.5 denier.

[0012] this invention also offers a wiper which consists of this hydrophilic nonwoven fabric.

[0013]

(State of embodiment of this invention)

The nonwoven fabric of this invention consists of synthetic fiber or semi-synthetic fiber. The fiber substrate used in this invention is not limited specifically and it can be any general synthetic fiber or semi-synthetic fiber. Among these, hydrophobic fibers are preferred since it has no hydrophilic nature and also works well in this invention when it is kneaded and mixed with a hydrophilic agent and treated using a plasma electric discharge process. The hydrophobic fiber used in this invention should be polyolefin or polyester based fiber because of their general purpose features.

[0014] The polyolefin used in this invention has alpha-olefin such as ethylene, propylene, butene-1 as its main monomer component. Specific examples include co-polymers of polyethylene such as polypropylene, high-density polyethylene, middle-density polyethylene, low-density polyethylene, linear low density polyethylene, polyethylene/polypropylene co-polymer, etc.

[0015] The polyester used in this invention is not limited specifically. For example, there are polyethylene terephthalate which has terephthalic acid, 2,6-naphthalene

dicarbonate or esters of these as the main dicarbonic acid component, and also ethylene glycol or tetramethylene glycol as the main glycol component, polybutylene terephthalate, or linear polyester such as polyethylene 2,6 naphthalate and co-polymers of these.

[0016] As long as the synthetic or semi-synthetic fiber which constitutes the nonwoven fabric in this invention is mixed with a hydrophilic agent, it can be either a single fiber or a composite. In addition, the structure of the composite fiber can be a core-cap type structure, biased core cap type structure, parallel type structure, island type structure, etc.

[0017] It is also possible to use additives such as thermal stabilizers, dye improving agents, or coloring agents to the synthetic fiber or semi-synthetic fiber.

[0018] The hydrophilic agent kneaded with the synthetic or semi-synthetic fiber is not specifically limited, and conventional hydrophilic agents can be used. For instance, while the type of hydrophilic agent which is kneaded in polyolefin is not limited specifically, you can use glyceride, polyoxy alkylene fatty acid ester, and sulfonic acid metal salt compounds. In addition, while the hydrophilic agent which is kneaded in polyester is not limited specifically, you can use polyoxyethylene glycol, polyethylene glycol, compounds with groups which have a polyalkylene oxide chain bonded to a polyalkylene polyamine base.

[0019] The amount of hydrophilic agent kneaded with the synthetic or semi-synthetic fiber differs depending on the kinds of hydrophilic agent to be used. As long as it is in the range where the thread forming process stability and the breaking strength of the nonwoven fabric is not lowered, there is no limitation. However, a desirable amount is in the range of 0.1 to 10 %. If the amount is lower than 0.1 %, sufficient hydrophilic properties do not appear even with the plasma electric discharge process. On the other hand, if it is higher than 10 %, stable thread forming will be difficult. Also, in this invention, by giving plasma electric discharge process to nonwoven fabric which is made of fiber which has been kneaded with a hydrophilic agent, good hydrophilic properties are attained. Therefore, it is not necessary that the base fiber be hydrophilic.

[0020] There is no specific limitation on the method used to knead the fiber with the hydrophilic agent, and conventional methods can be used. For instance, there is a method where the hydrophilic agent is melted and mixed with the synthetic fiber in a master batch and then pellets are melted and mixed with synthetic resin; there is a method where an inorganic substance such as magnesium stearate is added to the hydrophilic agent and made into pellets and chip-blended with synthetic resin pellets; there is a method where a hydrophilic agent is melted and mixed in the synthetic resin.

[0021] There are several methods for manufacturing nonwoven fabric from synthetic or semi-synthetic fiber which has been kneaded with a hydrophilic agent. The following are examples: each process - melting and thread forming, drawing, shrinking, thermal processing, and cutting, is done by conventional methods. Then nonwoven fabric is acquired by roller card methods or span bonding methods which manufactures nonwoven fabric directly with melted threads; melt blow methods, burst fiber methods, and wet type paper making methods which consist of cutting threads which have gone through a thread stroke forming process short and putting this through dispersion, webbing, and crossing processes. For acquiring nonwoven fabric which has small stitches, melt blow methods are is preferred. For acquiring nonwoven fabric which has extremely high uniformity, wet paper making methods are preferred.

[0022] In addition, in order to improve the strength of the nonwoven fabric, it is acceptable to partially bond the fibers by thermal methods using an embossing roll, etc. In addition, it is possible form fiber crossing routes by water jet methods or by needle punching.

[0023] The most suitable synthetic or semi-synthetic fiber which constitutes the nonwoven fabric of this invention should have the following properties.

[0024] The fiber should have 0.03 to 1.5 denier, preferably 0.1 to 1 denier. If it exceeds 1.5 denier, the surface area of the wiper is too small, and wiping performance is lowered. On the other hand, if it is less than 0.03 denier, thread forming when the hydrophilic agent is kneaded becomes even more difficult and the tensile strength of the nonwoven fabric is low. In this case, the wiper may tear easily or make dust.

[0025] The hydrophilic nonwoven fabric of this invention may consist of a single synthetic or semi-synthetic fiber which has been kneaded with a hydrophilic agent. As long as it is in the range which does not damage its function, it can be made with synthetic or semi-synthetic fiber which has not been kneaded with a hydrophilic agent. Other fibers can also be included.

[0026] The hydrophilic nonwoven fabric of this invention is acquired by applying a plasma electric discharge process to nonwoven fabric that consists of synthetic or semi-synthetic fiber which has been kneaded and mixed with a hydrophilic agent. The plasma electric discharge process in this invention is performed by exposing a nonwoven fabric web to a substance which is in a plasma state. "Plasma state" means that an inert gas is dissociated into negatively and positively charged particles by applying a high voltage or heating it to a high temperature. Desirable methods of applying high voltage are spark electric discharge, corona electric discharge, or glow electric discharge, etc. In addition, the inert gas must not be polymerized under high voltage. Appropriate gasses

include oxygen, hydrogen, nitrogen, argon, helium, gas, etc. If the pressure of the inert gas during the high voltage is less than 0.01 Torr, reforming is not sufficient. On the other hand, if it exceeds 20 Torr, there are too many gas molecules, the strength of the plasma goes up, and breaking of small fibers occurs, which is not preferred.

[0027] Among these plasma electric discharge processing methods, in order to process large amounts of nonwoven fabric continuously and because of simplicity and ease of processing, an atmospheric pressure corona electric discharge process is most desirable.

[0028] In this corona electric discharge process, an appropriate space is set up between a rotating roll and an electrode connected to a high voltage device, and a high voltage corona is produced by applying up to 10,000 volts at high frequency. The nonwoven fabric is passed through this space at an appropriate speed. By reacting with ozone or nitrogen oxide produced by the corona , the nonwoven fabric surface forms, hydrophilic groups such as carboxyl groups, hydroxyl groups, or peroxide groups. These hydrophilic groups will contribute to the improvement of hydrophilic properties of the nonwoven fabric and its continuous features.

[0029] The corona electric discharge process conditions should provide a total energy per side of 0.05 to 2.0 KW min./m^2.

[0030] When the total energy per side is smaller than 0.05 KW min.m^2, although the hydrophilic properties are improved compared to the case when the corona process is not done, it is possible to improve the hydrophilic properties and their durability by performing treatment in the range of this invention. A wiper with excellent liquid-retention and wiping effectiveness can be attained. If the power density exceeds 2.0 KW min./m^2, the hydrophilic properties are not improved much more.

[0031]

(Examples of practice)

In the following, the hydrophilic nonwoven fabric of this invention is going to be explained using examples of practice. However, this invention is not limited to these examples only. Also, "parts" and "%" in example of practice means each "weight part" and "weight %".

[0032] The evaluation methods concerning the hydrophilic nonwoven fabric of this invention are explained beforehand in the following. The words used in tables 1 to 3 are as follows:

hydrophilic agent kneading; kneaded amount of hydrophilic agent (%)

corona electric discharge process; condition of corona electric discharge process (kW min/m^2)

[0033] (water-absorbing speed 1)

Water absorbing speed was used as a guideline for the hydrophilic properties of the nonwoven fabric in this example of practice. Water-absorbing speed is measured by observing the amount of time it takes for a mirror surface reflection to disappear. The time is measured in seconds. The test method is as follows. First, a 200 x 200 mm sample piece was prepared. This test piece was attached to the retaining frame described in JIS L 1907. It was adjusted so that the distance from the surface of the sample piece to the top of the burette was 100 mm. Next, a single drop of water was dropped from the burette , and the elapsed time from when the water drop reached the surface of the sample piece until the water drop stopped special reflection was measured using a stop watch. This operation was done for 5 test samples, and their average value was taken as the water-absorbing speed. In addition, when the water drop stopped special reflection instantly, it was stated as less than 0.2 in the table. When the water drop was not absorbed even after 600 or more seconds, it was stated as more than 600 in the table.

[0034] (water-absorbing speed 2)

After the samples were left for 200 days at 20 C and 65 % relative humidity, the water-absorbing speed was measured again by the same method.

[0035] (breaking strength)

Following method stated in JIS L 1096, breaking strength in the vertical direction was measured. However, the sample was 50 mm wide and 200 mm long, and each of the 5 samples was measured at 100 mm intervals, and tensile strength was expressed by the average value. Units are N/50 mm.

[0036] (Wiping feature 1)

2 cc of a liquid (water or ethanol) was dropped on a glass plate, and it was wiped lightly using a 100 mm x 100 mm square sample piece. The remaining liquid was observed and evaluated. When there was hardly any remaining liquid, the test result was marked as O; if liquid remained slightly, the test result was marked as triangle shape; and when most of the liquid remained, the test result was marked as X.

[0037] (Wiping feature 2)

After the sample was left for 200 days at 20 C and 65 % of relative humidity, the wiping feature was measured again by the same method.

[0038] (Example of practice 1)

Long-fiber nonwoven fabric was acquired by span bond methods from polypropylene which had been kneaded with 2.0 wt. % of a hydrophilic agent which consisted of stearoyl monoethanol amide and alkyl sulfonate sodium with 15 average

carbon number. The polypropylene pellets were melted and formed into thread by pulling by an ejector and collected on a moving net to form a web. The long fiber in the acquired nonwoven fabric had 0.5 denier. This nonwoven fabric was partially thermally pressed and deposited by an embossing roll which had been heated to 135 C, and a long fiber nonwoven fabric sheet with 50 g/m^2 stitch and 250 um thickness was acquired. After that, a corona electric discharge process was applied to both sides of the nonwoven fabric at 1.0 KW min./m^2 total energy per side, and the nonwoven fabric of example of practice 1 was manufactured.

[0039] (Example of comparison 1)

Except that it did not use a hydrophilic agent, example of practice 1 was followed, and a nonwoven fabric which consisted of polypropylene fiber was acquired. This nonwoven fabric was partially thermally pressed and deposited, and a long fiber nonwoven fabric sheet with 50 g/m^2 stitch and 250 um thickness was acquired. After that, a corona electric discharge process was applied to both sides of the nonwoven fabric at 1.0 KW min./m^2 total energy per side, and the nonwoven fabric of example of comparison 1 was manufactured.

[0040] (Example of comparison 2)

Nonwoven fabric was acquired by the same method as example of practice 1 without applying the corona electric discharge process, and the nonwoven fabric of example of comparison 2 was manufactured.

[0041] (example of comparison 3)

Except that it included 12.0 wt. % of hydrophilic agent, example of practice 1 was followed, and a long fiber nonwoven fabric which consisted of polypropylene fiber was acquired. Without applying the corona electric discharge process, the nonwoven fabric of example of comparison 3 was manufactured. The nonwoven fabrics acquired from example of practice 1 and examples of comparison 1 to 3 were evaluated according to tests described above. Results are shown in table 1.

[0042]

table 1

property	Example of practice 1	Examples of comparison		
		1	2	3
Hydrophilic agent used	2	none	2	12
Corona discharge	1.0	1.0	none	none
Absorbing speed 1	<0.2	<0.2	>600	50
Absorbing speed 2	15	>600	>600	200
Tensile strength	130	140	130	20
Water				
Wiping performance 1	O	O	X	O
Wiping performance 2	O	X	X	Δ
Ethanol				
Wiping performance 1	O	O	Δ	O
Wiping performance 2	O	Δ	Δ	O

[0043] As shown in table 1, the fabric made by the method in this invention was superior in hydrophilic properties, and its wiping feature was also good. On the other hand, although example of practice 1 containing no hydrophilic agent showed good hydrophilic properties right after corona electric discharge process , deterioration of the hydrophilic properties over time was intense. It was obvious that it hardly had any hydrophilic properties after 20 days. In addition, from example of comparison 2, it was found that even though hydrophilic agent was included, fabric which did not have a corona electric discharge process had no hydrophilic properties at all. Since example of practice 1 applied a corona electric discharge process to the same nonwoven fabric as in example of comparison 2, this proves that the use of hydrophilic agent produced a hydrophilic fabric even when the fiber itself did not have good hydrophilic properties. Although example of comparison 3 which used a large amount of hydrophilic agent had a certain degree of hydrophilic properties without the corona electric discharge process, the breaking strength of the long fiber nonwoven fabric was low. In addition, threads were cut in many cases during the thread forming process, and stable production was thought to be difficult.

[0044] (example of practice 2)

Except that the corona electric discharge process output was changed to 0.03 KW min./m^2, example of practice 1 was followed, and the nonwoven fabric of example of practice 2 was manufactured.

[0045] (example of practice 3)

Except that the corona electric discharge process output was changed to 0.05 KW min./m^2, example of practice 1 was followed, and the nonwoven fabric of example of practice 3 was manufactured.

[0046] (example of practice 4)

Except that the corona electric discharge process output was changed to 2.0 KW min./m^2, example of practice 1 was followed, and the nonwoven fabric of example of practice 4 was manufactured.

[0047] (example of practice 5)

Except that the corona electric discharge process output was changed to 3.0 KW min./m^2, example of practice 1 was followed, and the nonwoven fabric of example of practice 5 was manufactured. The nonwoven fabrics acquired from examples of practice 2 to 5 were evaluated according to the above test methods. Results are shown in table 2.

[0048]

table 2

property	Examples of practice			
	2	3	4	5
Hydrophilic agent used Corona discharge	2.0 0.03	2.0 0.05	2.0 2.0	2.0 3.0
Absorbing speed 1 Absorbing speed 2 Tensile strength	<0.2 20 130	<0.2 10 130	<0.2 10 130	<0.2 10 130
Water Wiping performance 1 Wiping performance 2	 O O	 O O	 O O	 O O
Ethanol Wiping performance 1 Wiping performance 2	 O O	 O O	 O O	 O O

[0049] From example of practice 2 to 5, it was found that hydrophilic nonwoven fabric with high wiping features could be acquired even if the corona processing was changed. Therefore, it was found that hydrophilic nonwoven fabric with high wiping feature was acquired.

[0050] (Example of practice 6)

Polyethylene terephthalate was melted. Next, a hydrophilic agent consisting of 5 wt. % of N-polyoxy alkylene polyalkylene polyamine compound and small amount of hehyndard(?phonetic translation) phenol base antioxidant were kneaded in the melted polymer. After that, it was uniformly mixed in a static mixer, and then it was extruded from a round nozzle at 285 C and made into coils. The original thread was drawn 390 % in a water bath at 75 C, and oil was added at 0.1 wt. %. Next, it was processed for loosening for 10 minutes at 150 C. After it was cut into 51 mm lengths, single fibers with 1.0 denier were acquired. After that, it was made into a fiber web by passing through a card and random webber. In the fiber web, a crossing process was done by high pressure water jet at 30 kg/cm^2, and a short fiber nonwoven fabric sheet with 50 g/m^2 average

stitch was acquired. Next, a corona electric discharge process was given to both sides of the nonwoven fabric at 1.0 KW min./m^2 total energy per side, and the nonwoven fabric of example of practice 6 was manufactured.

[0051] (Example of comparison 4)

Except that it did not contain a hydrophilic agent, example of practice 1 was followed, and a short fiber nonwoven fabric which consisted of polyester fiber was acquired. After that, a corona electric discharge process was given to both sides of the nonwoven fabric at 1.0 kW min./m^2 total energy per side, and the nonwoven fabric of example of comparison 4 was manufactured.

[0052] (Example of comparison 5)

Long fiber nonwoven fabric was acquired by the same method as example of practice 6. Without using a corona electric discharge process, the nonwoven fabric of example of comparison 5 was manufactured. The nonwoven fabrics acquired from example of practice 6 and examples of comparison 4 and 5 were evaluated according to the above test methods. Results are shown in table 3.

[0053]

table 3

property	Ex of practice	Ex of comparison	
	6	4	5
Hydrophilic agent used Corona discharge	5.0 1.0	1.0	5.0
Absorbing speed 1 Absorbing speed 2 Tensile strength	<0.2 3 80	<0.2 >600 80	>600 >600 70
Water Wiping performance 1 Wiping performance 2	 O O	 O X	 X X
Ethanol Wiping performance 1 Wiping performance 2	 O O	 O Δ	 Δ Δ

[0054] As indicated in table 3, even for nonwoven fabric which consisted of polyester base fiber, the product of this invention has excellent hydrophilic properties, and its wiping features were good as well.

[0055]

(Effects of this invention)

The hydrophilic nonwoven fabric of this invention is acquired by applying a plasma electric discharge process to nonwoven fabric that consists of either single or mixed synthetic or semi-synthetics fiber which are kneaded and mixed with a hydrophilic agent. Not only are the hydrophilic properties right after the plasma electric discharge process good, it also has less hydrophilic deterioration due to passing time. This hydrophilic nonwoven fabric has excellent mechanical features such as breaking strength. This invention offers such hydrophilic nonwoven fabric and wipers which use this nonwoven fabric.